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Original communication

# Characteristics of cardiovascular deaths in forensic medical cases in Budapest, Vilnius and Tallinn

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ABSTRACT

Evaluation of the pathomorphological characteristics of cases involving natural and sudden cardiovascular death is essential for the determination of the cause of death. The main purpose of this study is to investigate sudden unexpected cardiovascular death and to study how different geographical climatic influences may affect cardiac mortality in three capitals: Budapest, Vilnius and Tallinn. There were 8482 (5753 male, 2729 female) cardiovascular deaths between 2005 and 2009. The highest rate was observed in the age group between 71 and 80 years (35.17%) and 51–60 years (24.45%). The highest number of cardiovascular deaths occur in January (805/9.49%) and December (770/9.07%). Seasonal distribution was observed, with winter prevalence in Tallinn (279/3.20%) and spring prevalence in Vilnius (760/8.90%). Though in Vilnius and Budapest a great number of deaths occurred in winter and spring, any correlation with other factors (e.g. age, gender, BAC) was not statistically significant. Based on our results we can conclude that environmental–geographical parameters may affect natural cardiovascular death. Examination of pathological patterns and predisposing environmental parameters may help to improve prevention strategies.



## 1. Introduction

Cardiovascular diseases are the leading cause of mortality worldwide. Well-known risk factors include hypertension, smoking, diabetes, and hyperlipidaemia that elicit atherosclerosis, a common background to the development of ischaemic heart disease and peripheral arterial occlusions.[1] Several studies have demonstrated that cardiovascular mortality has a characteristic seasonal distribution,[2] and the inverse relationship between average daily temperatures and ischaemic heart disease mortality has also been shown.[3,4] Cold temperatures may be important triggering factors in the onset of life threatening cardiac events even in countries with relatively mild winters,[5] however, only few studies have examined the environmental differences between countries with different climate and geography.[6,7]

Examination of the pathomorphological characteristics of natural sudden cardiovascular death cases is essential for the determination of the cause of death. Examination of pathological patterns and predisposing environmental parameters may help to improve the prevention strategies. The main purpose of this study was to investigate sudden unexpected cardiovascular death and to study how different geographical climatic influences may affect cardiac mortality in three capitals: Budapest, Vilnius and Tallinn.

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## 2. Material and methods

### 2.1. Mortality data

In our study we collected cardiovascular death cases autopsied at the Forensic Departments of National Forensic Institutes in three capitals (Budapest, Vilnius and Tallinn) from the period of 2005–2009. The rate of cardiovascular mortality was 36.50% (Budapest: 4765 deaths), 18.30% (Vilnius: 2716 deaths) and 19.20% (Tallinn: 1001 deaths) among medico-legal autopsy cases. During these years the death rate (per 100,000 inhabitants) decreased in all three countries: in Hungary from 702.46 (in 2005) to 640.51 (in 2009), in Lithuania from 562.80 (in 2005) to 496.80 (in 2009) and in Estonia from 495.52 (in 2005) to 422.58 (in 2009). We have no data relating to overall cardiovascular mortality separately for cities. The 10th version of the International Classification of Diseases (ICD) was used. We applied the following codes: ICD 120.0 (unstable angina), ICD 125 (chronic ischaemic heart disease), ICD 105–109 (chronic rheumatic heart diseases), ICD 151.7 (cardiomegaly), ICD 142 (cardiomyopathy), ICD 150 (heart failure), ICD 170 (atherosclerosis), ICD 171 (aortic aneurysm and dissection), ICD 180 (phlebitis and thrombophlebitis), ICD 195–199 (other vascular disease).

We used the definition of sudden death defined by the World Health Organization (WHO), i.e., sudden death happens in 24 h after the first symptoms, in cases with no sign of previous diseases and no external cause of death or any sign of violence.[8]

The following parameters were evaluated: age, gender, cause of death, months of death, week days, BAC levels, place of death (private home, public institute, road, work place, hospital, ambulance, others). The BAC test was performed in most cases in Vilnius and Tallinn and about 10% of the cases of death in Budapest. We analysed blood alcohol concentrations (BAC) in a range of categories: slight (BAC: 51–80 mg/100 ml), mild (BAC: 81–150 mg/100 ml), moderate (BAC: 151–250 mg/100 ml), severe (BAC: 251–350 mg/100 ml), and very severe (BAC: above 351 mg/100 ml). The tissue samples removed from the body were fixed in a 4% formaldehyde solution, and after embedding in paraffin, 3–4 μm sections were made. The haematoxylin and eosin stained slides were examined under a light microscope. When required, Masson's trichrome or Van Gieson's stain was used. Microscopical examination of heart and other tissue samples was performed in all cases in Vilnius and Tallinn, but not in every case in Budapest.

### 2.2. Statistical methods

Statistics were amassed using the STATA 10 statistical package and included a Pearson Chi-square test for dichotomous variables, 2-ways summary table method, and the Spearman rank order correlations. A $p$-value of $\leq 0.05$ was considered as statistical differences.

## 3. Results

In our material there were 8482 (5753 male and 2729 female) cardiovascular deaths between the years 2005 and 2009 in Budapest, Vilnius and Tallinn. The mean age was 64.07 ± 14.33 year. Male predominance was observed in all the three capitals (Table 1), and 59.83% (5075) of cases involved males over the age of 60. Table 2 demonstrates the distribution of cardiovascular deaths in different age groups. The highest rate was observed in the age group of 71–80 years (35.17%) and 51–60 years (24.45%). Our data suggests that under the age of 40 years the rate of cardiovascular death is rare (4.33%). The most common cause of death in each capital was chronic ischaemic heart disease: Budapest: 40.23%; Vilnius: 77.10%; Tallinn: 37.36%. Acute cardiac illnesses were detected most frequently in Tallinn (15.78%) rather than in Budapest (5.58%) or Vilnius (0.11%).

**Table 1**
Cardiovascular death cases in Budapest, in Vilnius and in Tallinn.

| Capital | Female No (%) | Male No (%) | All No (100%) |
|---|---|---|---|
| Budapest | 1739 (36.5) | 3026 (63.5) | 4765 |
| Vilnius | 720 (26.5) | 1996 (73.5) | 2716 |
| Tallinn | 270 (26.9) | 731 (73.1) | 1001 |
| All | 2729 | 5753 | 8482 |

mean age: 64.07 ± 14.33 years.

A BAC test was done in 513 (10.77%) cases in Budapest, in 2704 (99.56%) cases in Vilnius and in 975 (97.40%) cases in Tallinn. Fig. 1 shows the post mortem BAC levels. In 2954 (70.47%) cases the BAC tests were negative. The BAC test was generally positive with victims with chronic ischaemic heart disease.

The highest number of cardiovascular deaths occurred in January (805/9.49%) and December (770/9.07%). In Vilnius and Budapest a great number of deaths occurred in winter and spring (Fig. 2), but correlation with other factors (e.g. age, gender, BAC) was not statistically significant. In Tallinn statistically significant seasonal distribution was observed with winter prevalence (280/3.30%). In Vilnius there was spring prevalence (760/8.90%) and in Budapest mortality data did not show seasonal distribution. There was a correlation (Fig. 3) between the winter period and old age (more than 56 years). During the winter period the mean age of victims was 66 year in Budapest, 63.5 year in Vilnius, and 61 year in Tallinn.

In addition, most cases were found dead on Mondays (1373/16.19%), in every capital. Most of the victims died at home (Budapest 45.50%, Vilnius 74.08%, Tallinn 45.60%), in hospital (Budapest 20.80%, Vilnius 3.17%, Tallinn 3.80%), or in a public place (Budapest 14.20%, Vilnius 8.65%, Tallinn 21.00%).

## 4. Discussion

### 4.1. Cardiovascular mortality

The survey target groups included victims of cardiovascular deaths during 2005–2009. We confirmed study results which showed that the most frequent cause of sudden death among adults is ischaemic heart disease.[8–11] International investigations found that about 20% of total mortality originated from cardiovascular diseases. Risk factors like smoking, high body weight, high blood pressure and high cholesterol level could cause ischaemic heart disease,[2,12,13] and a great number of other risk factors have to be taken into consideration. Cardiovascular mortality is multifactorial, however, in our study we focus on the similarities and differences detected in the three capitals. Comparing the three datasets we found that atherosclerosis was the most common cause of death in all of the three capitals. Our research showed that chronic cardiovascular death was the most frequent cause of death in Vilnius. The rate of acute cardiac events was the highest in Tallinn.

### 4.2. Climatic differences

Climatic and seasonal triggering factors have received increasing attention among risk factors of sudden death.[5,14] Estonia and Lithuania are located next to the Baltic Sea, in a higher line of latitude compared to Hungary. The climate is typically oceanic, with a lot of rainfall and cool summers, while Hungary has a continental climate, with less rainfall and higher average temperature. In our previous study[15] we observed that in Budapest there was a connection

**Table 2**
Distribution of cardiovascular deaths in different age groups.

| ICD codes | 0–20 years No (%) | 21–30 years No (%) | 31–40 years No (%) | 41–50 years No (%) | 51–60 years No (%) | 61–70 years No (%) | 71–80 years No (%) | ≥ 81 years No (%) | All (100%) |
|---|---|---|---|---|---|---|---|---|---|
| **ICD 120.0** | 1 (0.23) | – | 10 (2.34) | 48 (11.21) | 95 (22.20) | 116 (27.10) | 154 (35.98) | 4 (0.93) | **428** |
| **ICD 125** | 1 (0.02) | 27 (0.62) | 89 (2.03) | 469 (10.70) | 1095 (24.98) | 1132 (25.82) | 1539 (35.10) | 32 (0.73) | **4384** |
| **ICD 105–109** | – | 1 (1.41) | 3 (4.23) | 7 (9.86) | 15 (21.13) | 22 (30.98) | 23 (32.39) | – | **71** |
| **ICD 151.7** | – | 8 (1.69) | 21 (4.45) | 67 (14.19) | 135 (28.60) | 89 (18.86) | 146 (30.93) | 6 (1.27) | **472** |
| **ICD 142** | 10 (2.35) | 13 (3.06) | 37 (8.71) | 80 (18.82) | 125 (29.41) | 81 (19.06) | 72 (16.94) | 7 (1.65) | **425** |
| **ICD 150** | 13 (5.40) | 20 (8.30) | 19 (7.88) | 51 (21.16) | 57 (23.65) | 43 (17.84) | 34 (14.11) | 4 (1.66) | **241** |
| **ICD 170** | – | 1 (0.09) | 16 (1.41) | 58 (5.12) | 226 (19.95) | 243 (21.45) | 569 (50.22) | 20 (1.77) | **1133** |
| **ICD 171** | 1 (0.43) | 1 (0.43) | 10 (4.35) | 30 (13.04) | 43 (18.70) | 63 (27.40) | 82 (35.65) | – | **230** |
| **ICD 180** | 2 (0.90) | 5 (2.24) | 5 (2.24) | 18 (8.07) | 39 (17.49) | 28 (12.56) | 125 (56.05) | 1 (0.45) | **223** |
| **ICD 195–199** | 5 (0.57) | 13 (1.49) | 31 (3.54) | 138 (15.77) | 244 (27.89) | 198 (22.63) | 243 (27.77) | 3 (0.34) | **875** |
| **All** | **33 (0.39)** | **89 (1.05)** | **241 (2.84)** | **966 (11.39)** | **2074 (24.45)** | **2015 (23.76)** | **2987 (35.22)** | **77 (0.91)** | **8482** |

between cardiovascular death and daily mean temperature. Several studies have demonstrated that cardiovascular mortality has a seasonal distribution.[2,10,16–18]

The relationship between cold weather and ischaemic heart disease mortality is well established.[3,12,19,20] The relationship between increasing temperature and mortality has been reported since the early 20th century.[21–24] In our research the highest number of cardiovascular deaths occurred in January and December. Although in Vilnius and Budapest a great number of deaths occurred in winter and spring, however, correlation with other compared factors was not statistically significant. The seasonal distribution was observed with winter prevalence in Tallinn and with spring prevalence in Vilnius, and mortality data did not show seasonal distribution in Budapest. The detected seasonal distribution in the two Baltic capitals supports the hypothesis that cardiovascular death might be influenced by other meteorological and geographic factors, i.e., geographic location.[5,12,25]

### 4.3. Alcohol consumption

Studies on mice and human tissue have shown that alcohol is a direct myocardial toxin and causes ultrastructural damage.[26] Data obtained from most studies suggest that long-term alcohol consumption usually involves increased oxidative stress and production of pro-inflammatory cytokines and adhesion molecules that promote atherosclerosis plaque formation.[27] Alcohol consumption is another risk factor in cardiovascular disease and mortality; however there is no data about the drinking habits from the examined countries yet. In our data, the BAC test was generally positive with victims with chronic ischaemic heart disease.

### 4.4. Clinical references

The clinical data's from Hungary show that the marked temperature increase of the spring season, and the significant temperature decrease during autumn months also increases the number of AMI events. Many of the population are sensitive to temperature fluctuations and passing fronts. The high number of cold fronts during spring and warm fronts during autumn could have an effect on the increase of AMI incidence.[28] Several possible mechanisms have been proposed which could increase the risk of cardiac death and AMI in cold temperature. Cold stress has been found to result in blood pressure rises,[29,30] cardiac hypertrophy,[29] increased blood viscosity, and increased platelet counts.[30] A prospective study looking at the association between air temperature and risk factors for ischaemic heart disease concluded that the most important effects of cold temperature were on the haemostatic system, including increases in fibrinogen, and α2 macroglobulin.[30]

Our results suggest that there is a correlation between the winter period and old age. The cold season represents a significant risk for the elderly, anyone over 60 years of age. Other research, similar to our study, also found that elderly people are more sensitive to cold exposure. One reason for this is that older people are less able to maintain homeostasis in response to environmental challenges, as a result of age-related decline in various organs, such as a diminished ability of the kidney to conserve water.[31]

Based on our results we can conclude that there are several factors that may influence cardiovascular mortality. For example, environmental–geographical parameters may affect natural cardiovascular death. This study results support the hypothesis that a colder climate might represent a risk factor for elderly persons with chronic ischaemic heart diseases.

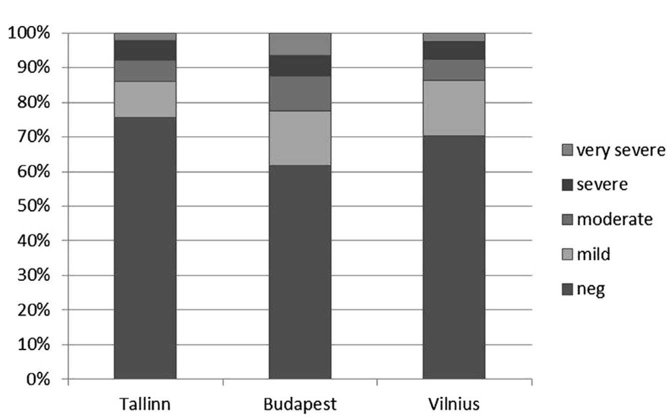


**Fig. 1.** Post mortem BAC levels in the three capitals.

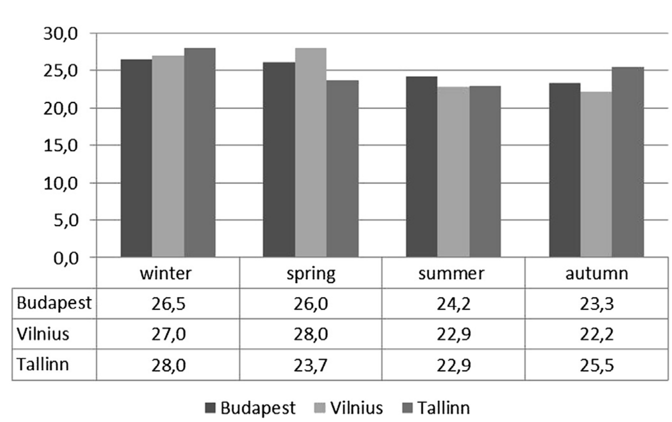


**Fig. 2.** Seasonal distribution of cardiovascular deaths (%).

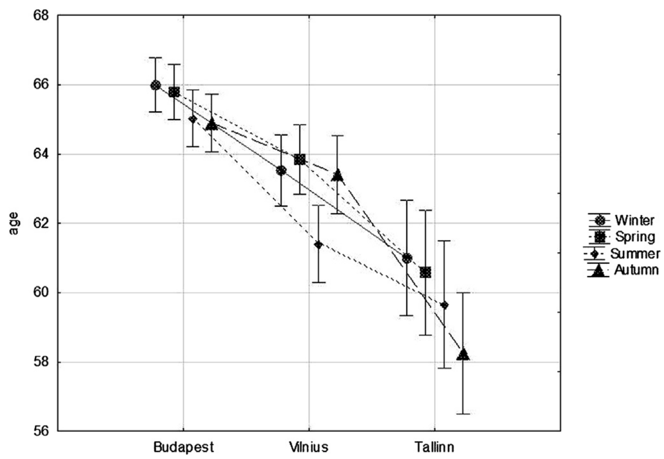


**Fig. 3.** Spearman Rank Order Correlation between seasons and old age groups (>56 years); Current effect: F(6.8387) = 1.3491, $p = 0.23138$; vertical bars denote 0.95 CI.

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